

# Designing Your Own Transformer

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Designing a transformer is not easy simply because the criteria involved with these devices are critical and elaborate. However some meticulously arranged data regarding the various calculations can make the procedure easier. Learn how to make a transformer through using simple formulas.

## Introduction

We have already studied a lot about transformers in Bright Hub and we know that it's simply a device used for either stepping-up or stepping down an applied input AC through magnetic induction in between its two windings.

Basically a transformer will have the following main components:

- Iron core stampings (configured either as U/T or E/I, generally the later is used more extensively)
- Central plastic or ceramic bobbin surrounded by the above iron core stampings
- Two windings (electrically isolated and magnetically coupled) using super enameled copper wire made over the bobbin
- Normally the winding which is designated to receive the input supply is termed as the "Primary" and the winding which in response to this input produces the required induced voltage as the output is termed as the "secondary" winding.

Designing your own transformer as per a specific application can be interesting, but not feasible without calculating the various parameters typically involved with them. The following discussion will take you through a few important steps and formulas and explain how to make a transformer.

## Calculating the Core Area (CA) of the Transformer

The Core Area is calculated through the formula given below:

$$CA = 1.152 \times \sqrt{(\text{Output Voltage} \times \text{Output Current})}$$

### Calculating Turns per Volt (TPV)

It is done with the following formula:

$$TPV = 1 / (4.44 \times 10^{-4} \times CA \times \text{Flux Density} \times \text{AC frequency})$$

where the frequency will depend on the particular country's specifications (either 60 or 50 Hz), the standard value for the flux density of normal steel stampings may be taken as 1 Weber/sq.m, for ordinary steel material the value is 1.3 Weber/sq.m

## Primary Winding Calculations

Basically three important parameters needs to be figured out while calculating the primary winding of a transformer, they are as follows:

- Current through the primary winding
- Number of turns of the primary winding
- Area of the primary winding

Let's trace out each of the above expressions:

**Primary Winding Current** = (Secondary Volts × Secondary Current) ÷ (Primary Volts × Efficiency), the average value for the efficiency of any transformer may be presumed to be 0.9 as a standard figure.

**Number of Turns** = TPV × Primary Volts

**Primary Winding Area** = Number of Turns / Turns per Sq. cm (from the **table A**)

Reading **Table A** is easy – just find out the relevant figures (wire SWG and Turns per sq.cm.) by tallying them with the closest matching value of your selected primary current.

### Secondary Winding Calculations

As explained above, with the help of **Table A** you should be able to find the SWG of the wire to be used for the secondary winding and the TPV simply by matching them with the selected secondary current.

The Number of turns for the secondary winding is also calculated as explained for the primary winding, however considering high loading conditions of this winding, 4 % extra turns is preferably added to the over all number of turns. Therefore the formula becomes:

Secondary Number of Turns = 1.04 × (TPV × secondary voltage),

Also secondary winding area = Secondary Turns / Turns per sq. cm. (from **table A**).

### Calculating the Core Size of the Steel Laminations or the Stampings

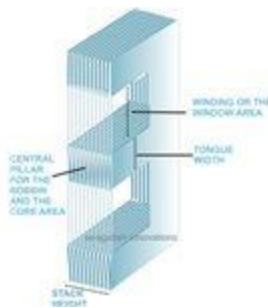
The core size of the steel stampings to be used may be easily found from **Table B** by suitably matching the relevant information with Total Winding Area of the transformer. The Total Winding Area thus needs to be calculated first, it's as follows:

Total Winding Area = (Primary Winding Area + Total Secondary Winding Area) × Space for External Insulation.

The third parameter i.e. the space for the insulation/former etc. may be taken approximately 25 to 35 % of the sum of the first two parameters.

Therefore, the above formula becomes:

Total Winding Area = (Primary Winding Area + Total Secondary Winding Area) × 1.3



Normally, a core having a square central pillar is preferred and used - other factors involved are also appropriately illustrated in the adjoining figure and calculated as follows:

Gross Core Area = Core Area from **Table B** / 0.9 (sq.cm.)

Tongue Width =  $\sqrt{\text{Gross Core Area}}$  (cm)

After calculating the Tongue Width, it may be used as a reference value and matched appropriately in **Table B** to acquire the actual CORE TYPE.

Your quest regarding how to make a transformer gets over when you finally finish calculating the stack height, using the formula:

$$\text{Stack Height} = \text{Gross Core Area} / \text{Tongue Width.}$$

### **Table A**

The table below helps you to select the gauge and turns per sq. cm of copper wire by matching them with the selected current rating of the winding appropriately.

#### **SWG----- (AMP)----- Turns per Sq.cm.**

10-----	16.6-----	8.7
11-----	13.638-----	10.4
12-----	10.961-----	12.8
13-----	8.579-----	16.1
14-----	6.487-----	21.5
15-----	5.254-----	26.8
16-----	4.151-----	35.2
17-----	3.178-----	45.4
18-----	2.335-----	60.8
19-----	1.622-----	87.4
20-----	1.313-----	106
21-----	1.0377-----	137
22-----	0.7945-----	176
23-----	0.5838-----	42
24-----	0.4906-----	286
25-----	0.4054-----	341
26-----	0.3284-----	415
27-----	0.2726-----	504
28-----	0.2219-----	609
29-----	0.1874-----	711
30-----	0.1558-----	881

31-----	0.1364-----	997
32-----	0.1182-----	1137
33-----	0.1013-----	1308
34-----	0.0858-----	1608
35-----	0.0715-----	1902
36-----	0.0586-----	2286
37-----	0.0469-----	2800
38-----	0.0365-----	3507
39-----	0.0274-----	4838
40-----	0.0233-----	5595
41-----	0.0197-----	6543
42-----	0.0162-----	7755
43-----	0.0131-----	9337
44-----	0.0104-----	11457
45-----	0.0079-----	14392
46-----	0.0059-----	20223
47-----	0.0041-----	27546
48-----	0.0026-----	39706
49-----	0.0015-----	62134
50-----	0.0010-----	81242

**Table B**

This Table B enables you to make your own transformer design by comparing the calculated Winding Area with the relevant required Tongue Width and Lamination Type number.

Type-----	Tongue-----	Winding No.-----	Width-----	Area
17(E/I)-----	1.270-----	1.213		
12A(E/12I)-----	1.588-----	1.897		
74(E/I)-----	1.748-----	2.284		
23(E/I)-----	1.905-----	2.723		

30(E/I)-----2.000-----3.000  
21(E/I)-----1.588-----3.329  
31(E/I)-----2.223-----3.703  
10(E/I)-----1.588-----4.439  
15(E/I)-----2.540-----4.839  
33(E/I)-----2.800-----5.880  
1(E/I)-----2.461-----6.555  
14(E/I)-----2.540-----6.555  
11(E/I)-----1.905-----7.259  
34(U/T)-----1/588-----7.259  
3(E/I)-----3.175-----7.562  
9(U/T)-----2.223-----7.865  
9A(U/T)-----2.223-----7.865  
11A(E/I)-----1.905-----9.072  
4A(E/I)-----3.335-----10.284  
2(E/I)-----1.905-----10.891  
16(E/I)-----3.810-----10.891  
5(E/I)-----3.810-----12.704  
4AX(U/T) -----2.383-----13.039  
13(E/I)-----3.175-----14.117  
75(U/T)-----2.540-----15.324  
4(E/I)-----2.540-----15.865  
7(E/I)-----5.080-----18.969  
6(E/I)-----3.810-----19.356  
35A(U/T)-----3.810-----39.316  
8(E/I)-----5.080-----49.803

Source:

<http://www.brighthubengineering.com/diy-electronics-devices/96783-designing-your-own-transformer/>